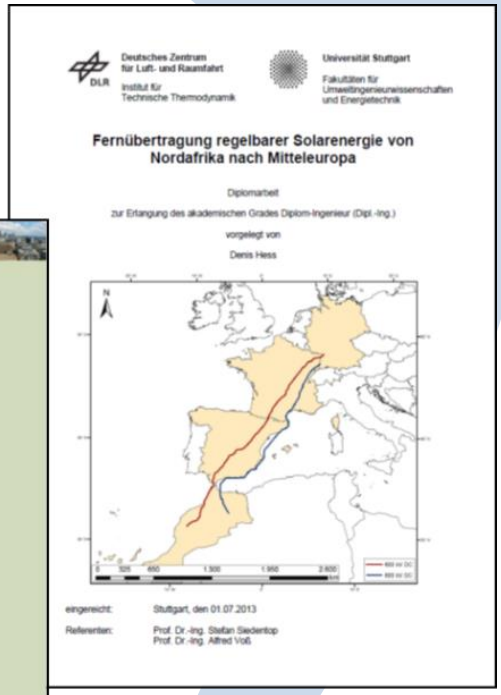
Transmission of dispatchable solar energy from North Africa to Central Europe

Dipl.-Ing. Denis Hess (DLR)

Rabat, 28.10.2013



Source: Hess, D. (2013): Fernübertragung regelbarer Solarenergie von Nordafrika nach Mitteleuropa

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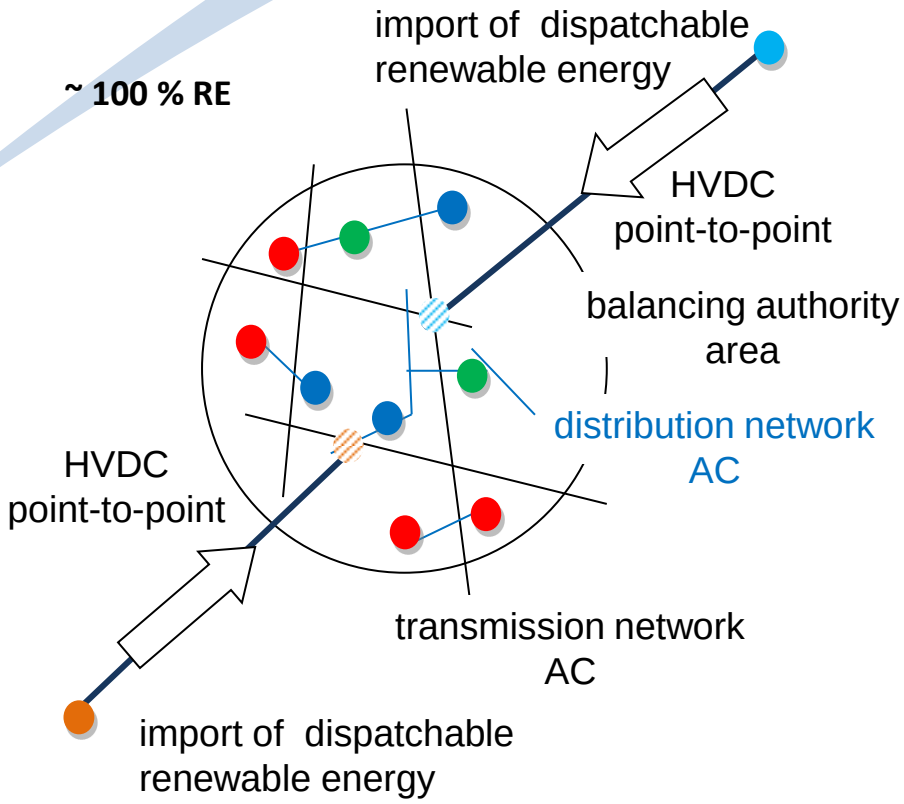
Examination area – Baden-Württemberg (BW)

decentralized renewable energies (RE) and storages

large power plants of dispatchable renewable energies

feeding point into the AC grid

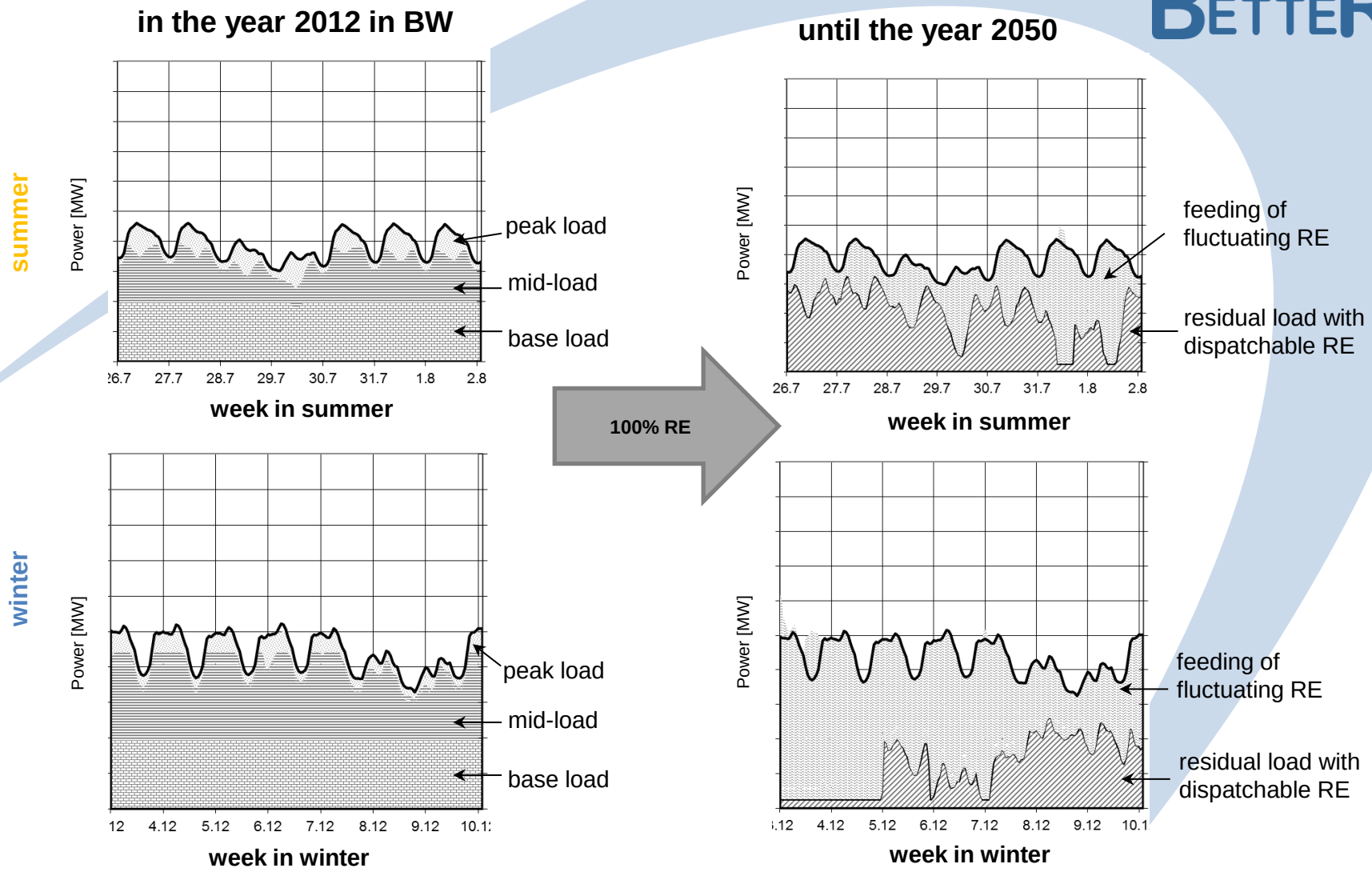


Examination area

10.8 mio. inhabitants, 80 TWh/y - in the year 2012

Source: (http://de.wikipedia.org/wiki/Baden-W%C3%BCrttemberg)

Paradigm change in the load range



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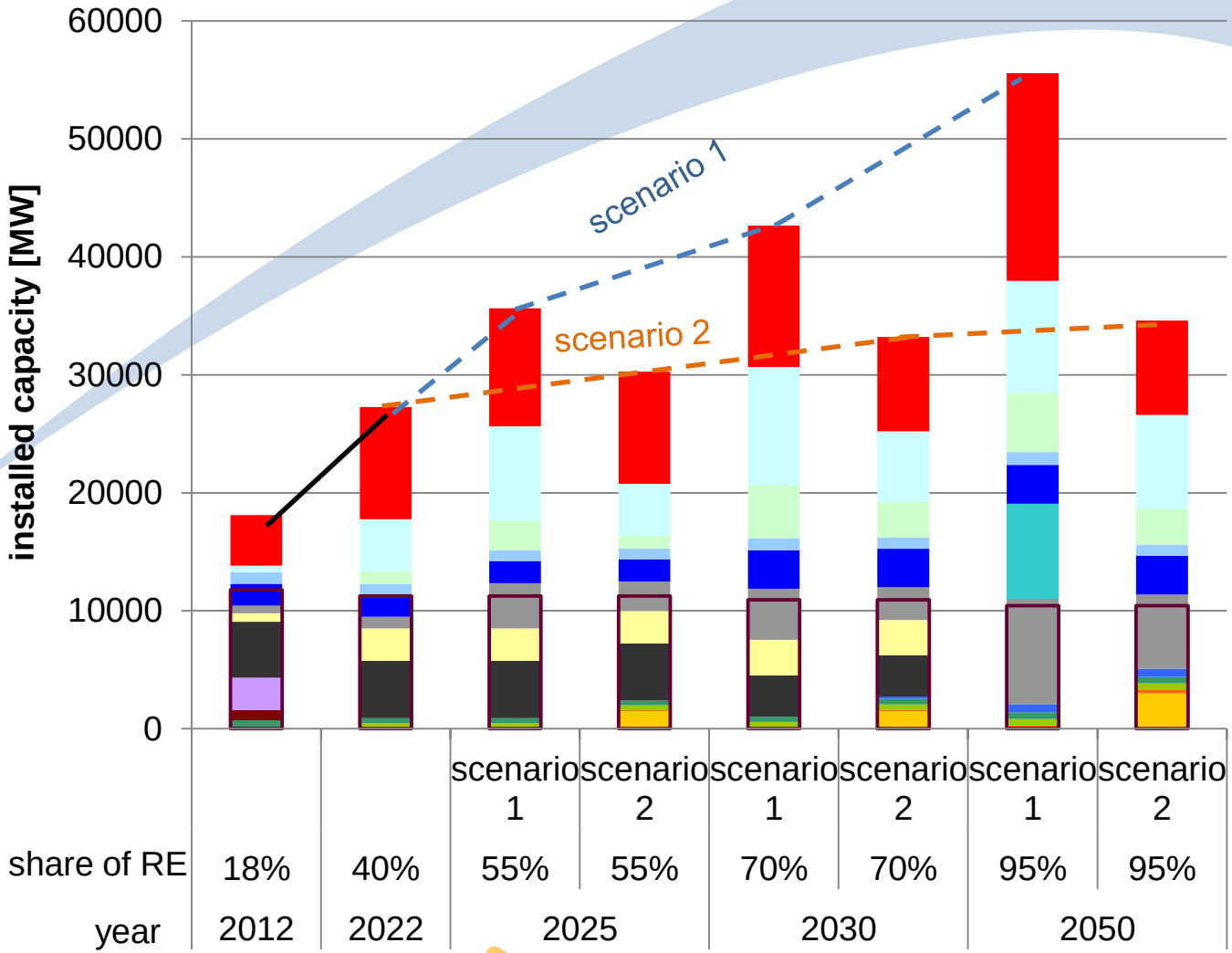
Renewable energies for Baden-Württemberg



- Photovoltaics
- Wind Onshore
- Wind Offshore
- River Runoff
- Pump Storage, CAES
- Hydrogen Storage
- Gas Turbines
- Combined Cycle
- Coal Plants
- Nuclear Plants
- Lignite Plants
- Import Hydro
- Wood, Biogas
- Biomass, Waste
- Geothermal
- Import CSP
- peak Load

The decision for scenario 2 is already TODAY necessary!

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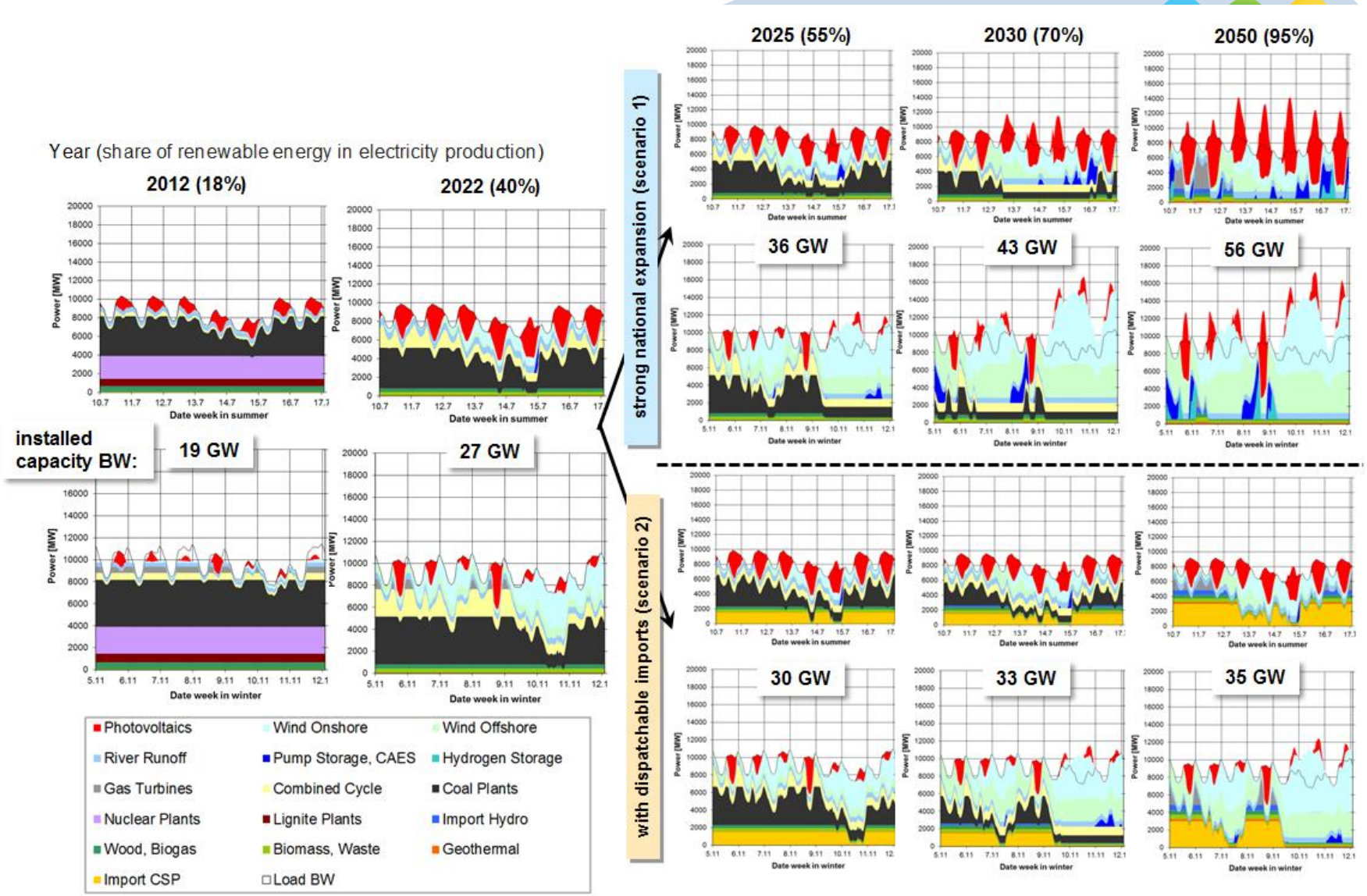
Time series of power production by type of power plant



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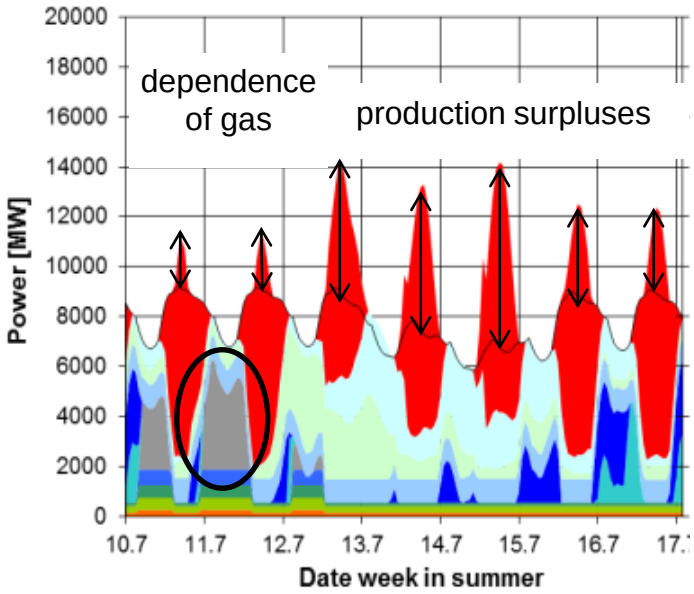
System problems in Baden-Württemberg in the year 2050 with 95% renewable energy (RE) in electricity supply

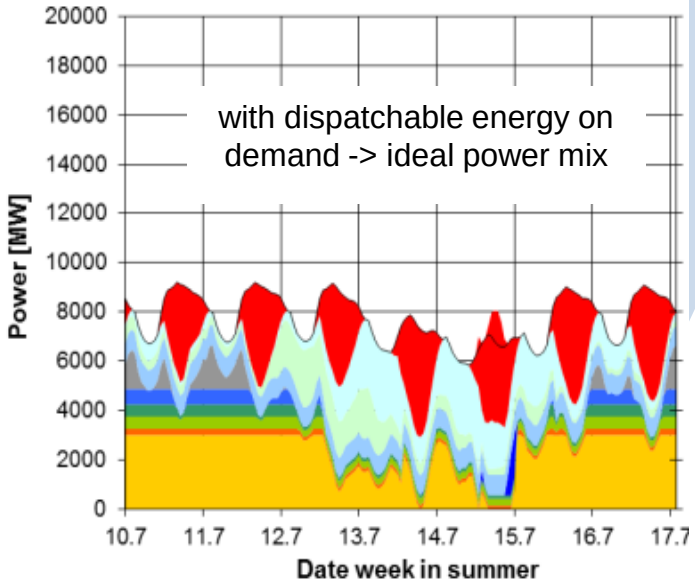
installed capacity: 55 GW



Quo vadis?

2050
95% RE

installed capacity: 35 GW



Photovoltaics | Wind Onshore | Wind Offshore | River Runoff | Pump Storage, CAES | Hydrogen Storage | Gas Turbines | Combined Cycle | Coal Plants
Nuclear Plants | Lignite Plants | Import Hydro | Wood, Biogas | Biomass, Waste | Geothermal | Import CSP | Load BW

Two scenarios for the year 2050, each with 95% renewable energies for the electricity supply in Baden-Württemberg

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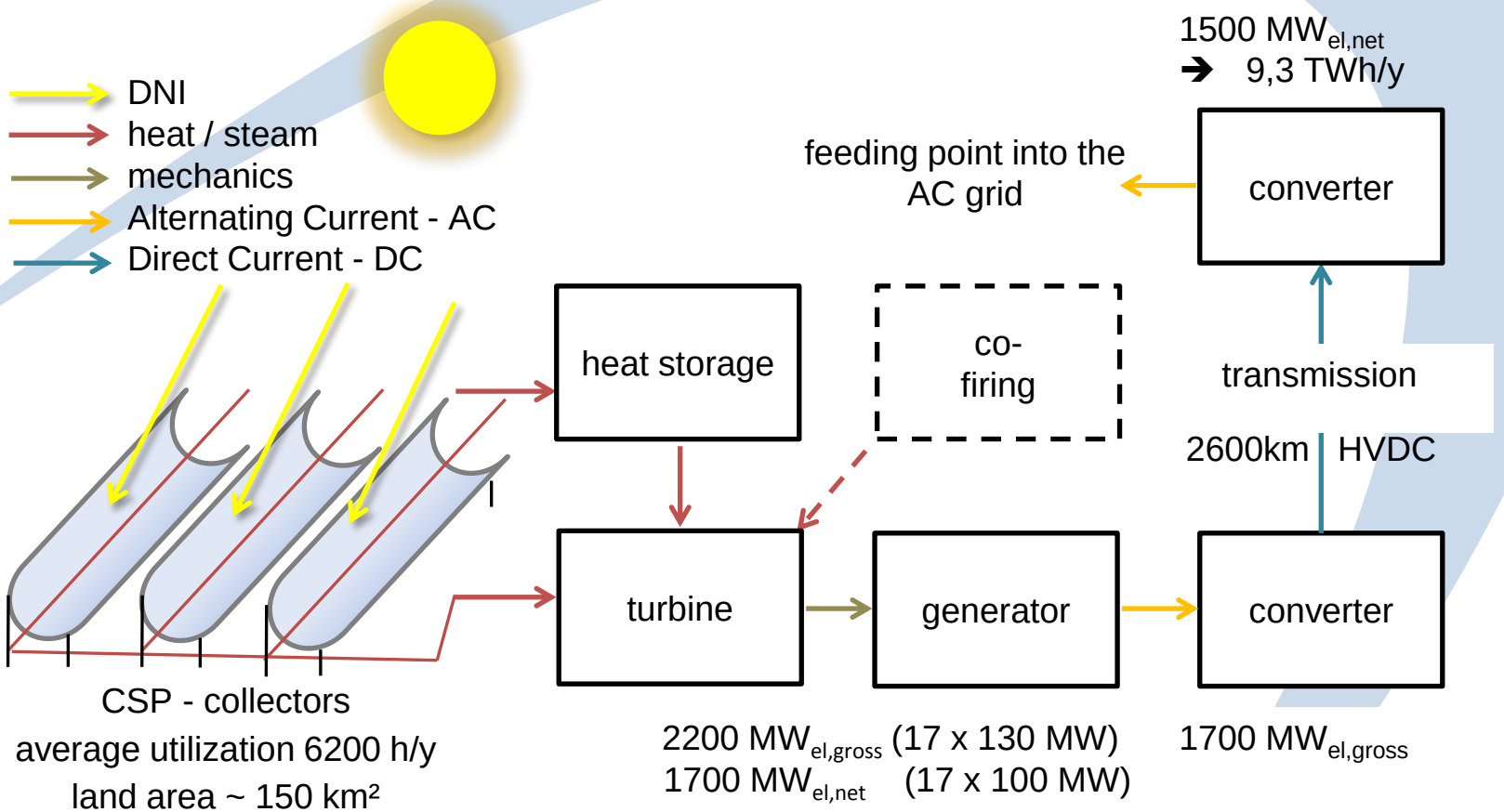
Transmission of dispatchable solar energy: CSP-HVDC site



DNI: Direct Normal Irradiance
CSP: Concentrating Solar Power
HVDC: High Voltage Direct Current

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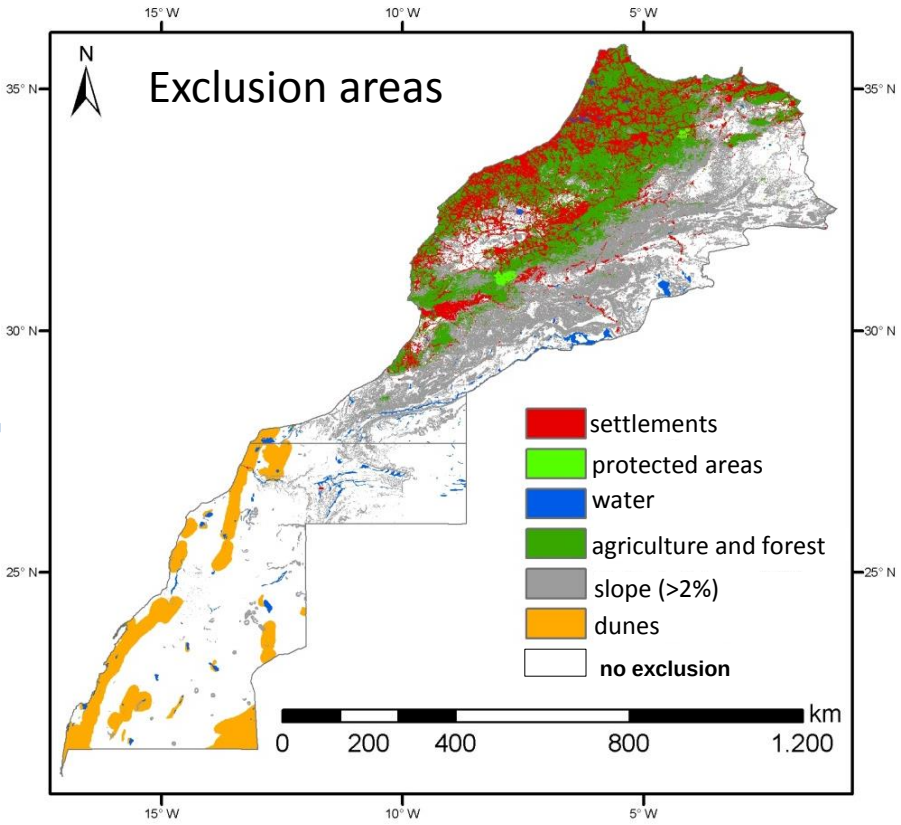
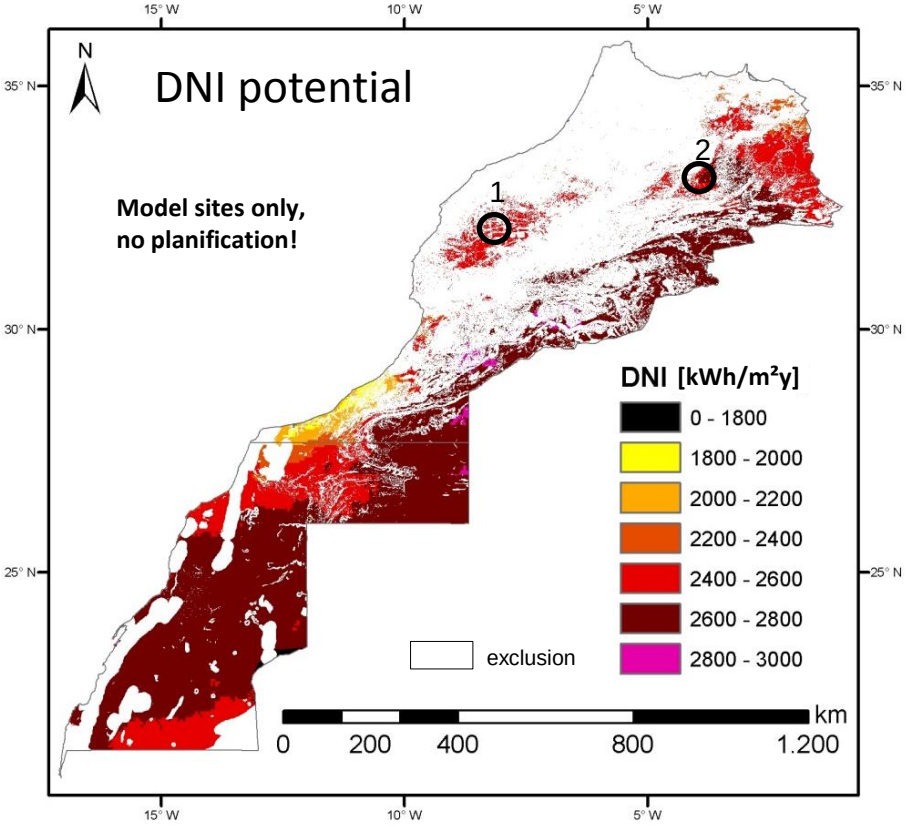
CSP model sites in Morocco





The economic **CSP potenital** in the northern part of Morocco is at about **8450 TWh/y** with **18500 km²** CSP gross land demand

-> one site with 150 km² needs **only 0.8% of this potential**

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First design of the CSP-HVDC site, cost and land requirements

MOR-E-F-D

HVDC 2600 km
1.7 GW / 1.5 GW_{net}
1,9 – 5,1 billion €
150 km²

CSP 2.2 GW
CSP 12 -18 billion €
150 km²

MOR-E-F-D

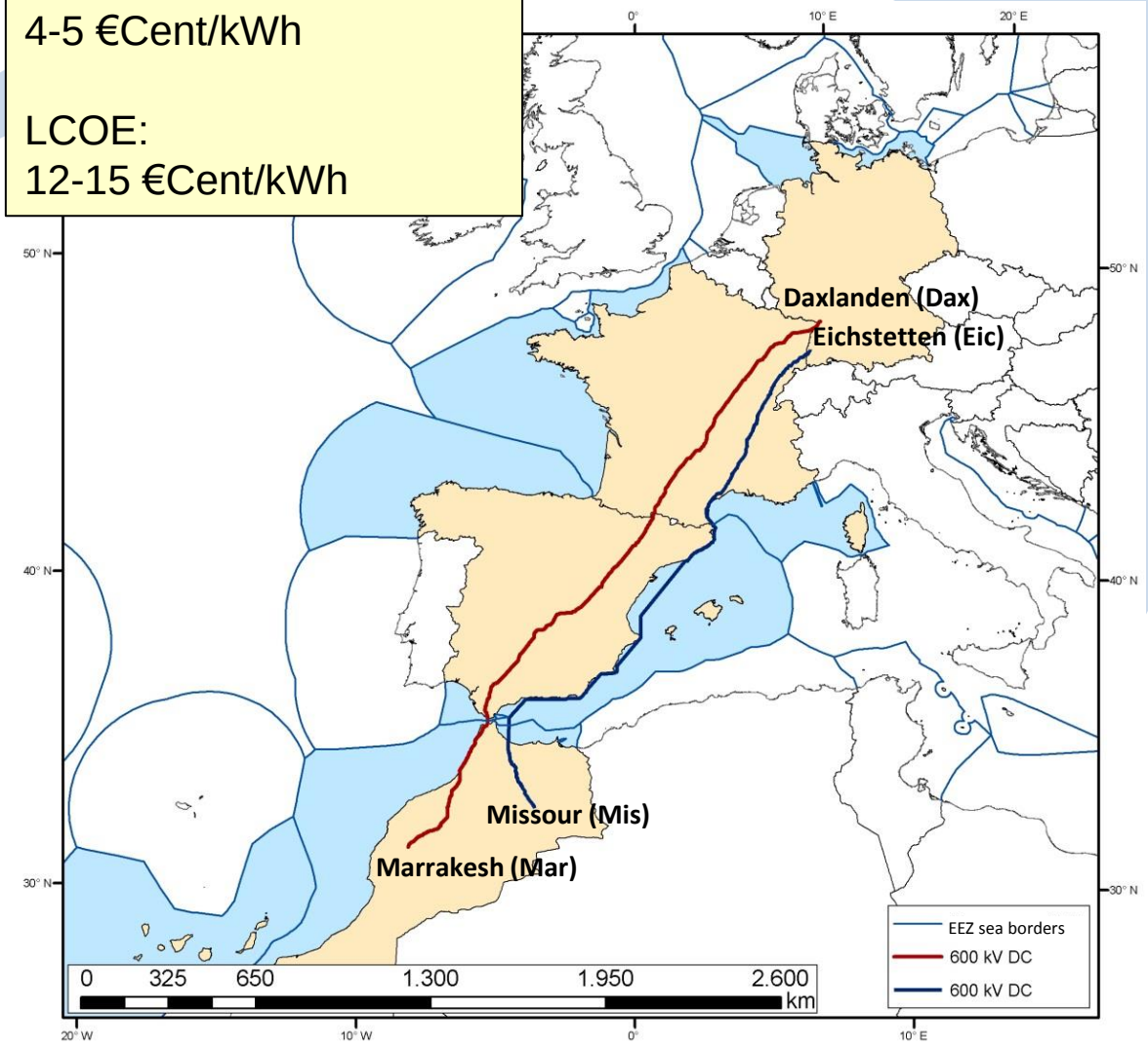
HVDC 2300 km
1.7 GW / 1.5 GW_{net}
3,7 – 4,9 billion €
75km²

CSP 2.2 GW
CSP 12 -18 billion €
150 km²

-> 9.32 TWh/a
16-23 billion € (real 2010)
feasible until 2024

O&M:
4-5 €Cent/kWh

LCOE:
12-15 €Cent/kWh



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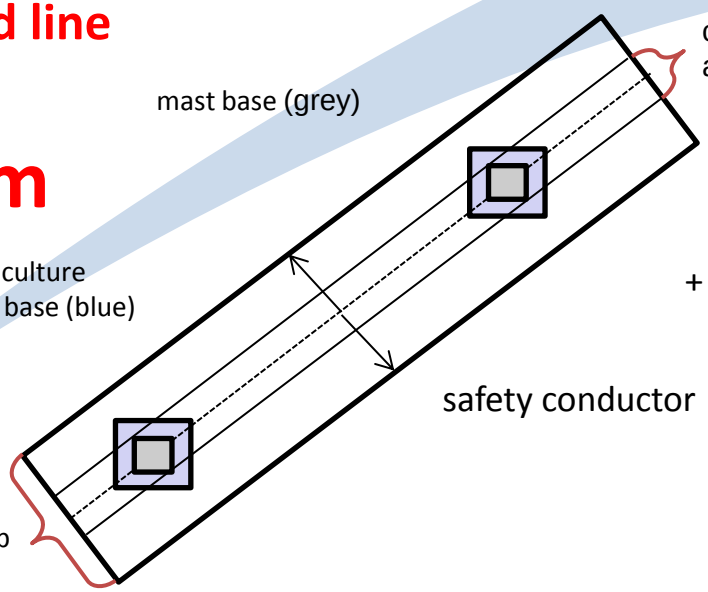
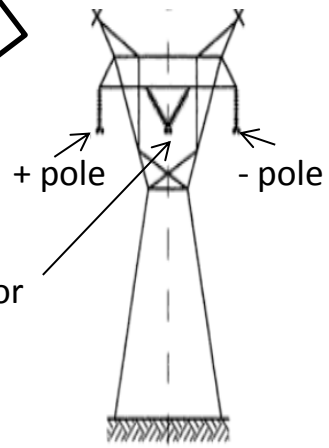
Adequate permanent payment for the required land

Overhead line

70 m

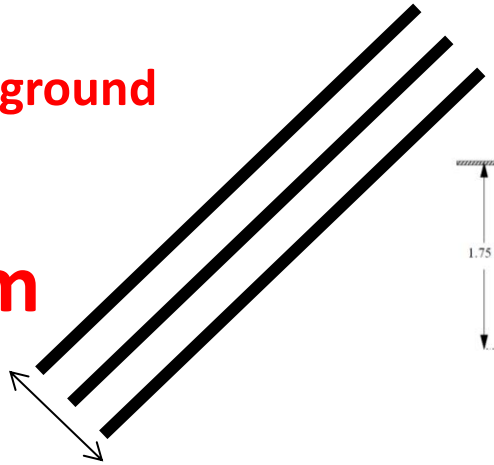
Restriction of agriculture through the mast base (blue)

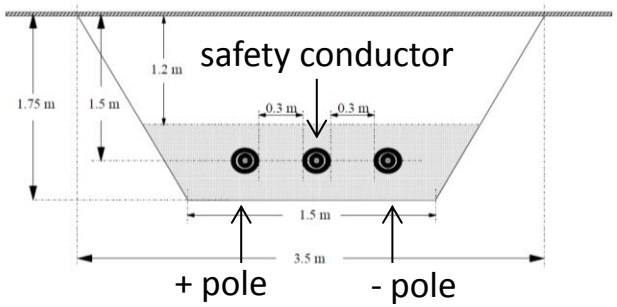




Underground cable

4 m





unit

$$\left[\frac{€Cent}{TWh \cdot m^2 \cdot y}\right]$$

cheaper overhead line and more expensive underground cable can reach through this compensation payment **cost neutrality** within their lifetime!

free choice of technology is made possible -> increased acceptance

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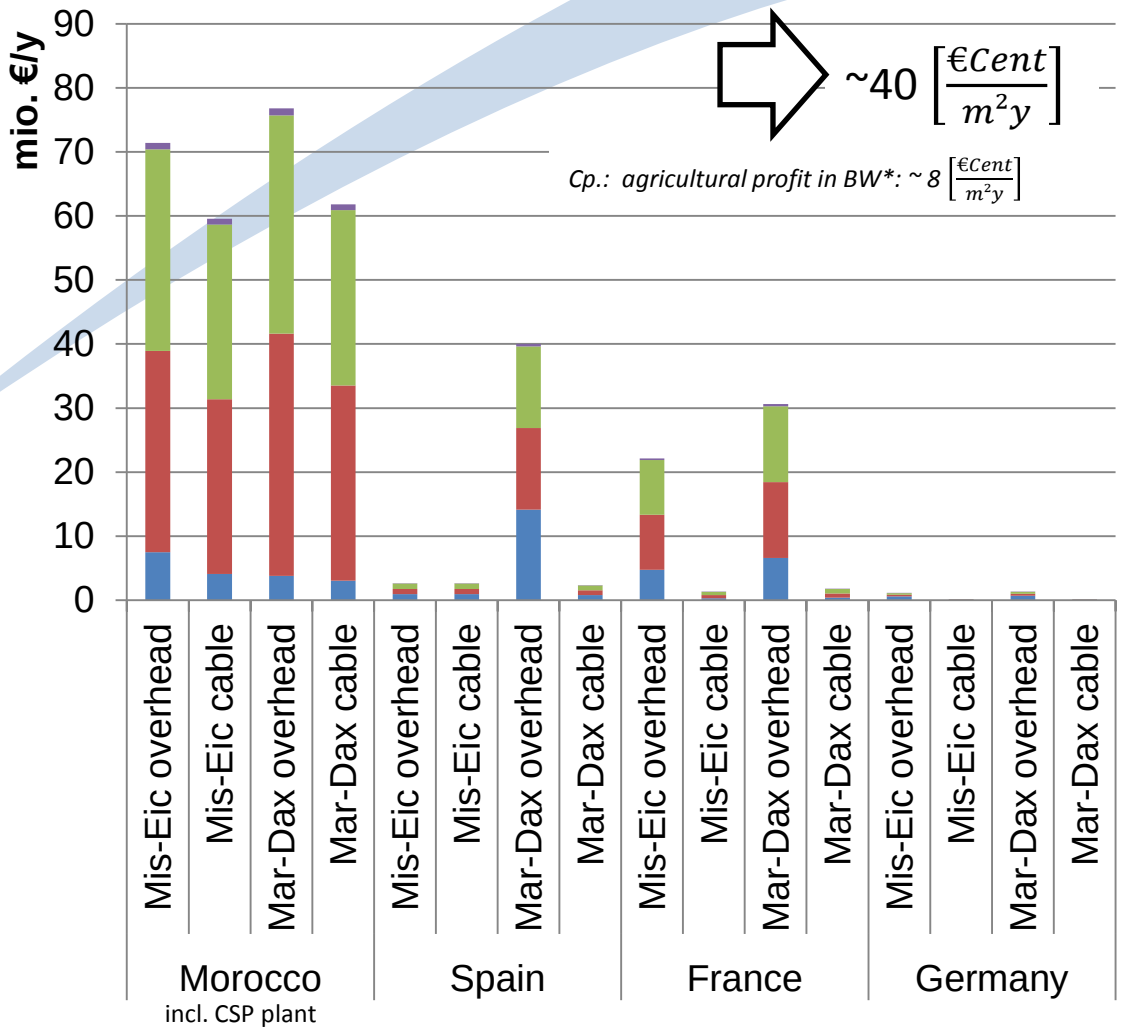
Annual income for the concerned nations, their municipalities and landowners (riparians) – each time with 4 routes



~40 $\left[\frac{€Cent}{m^2y}\right]$

Cp.: agricultural profit in BW: ~ 8* $\left[\frac{€Cent}{m^2y}\right]$

0.67 – 1.56 $\left[\frac{€Cent}{kWh}\right]$
costs for the consumers

- annual income for the nations and their municipalites from the concession fee
- annual income for the nations and their municipalites from tax of the motivation payment
- annual income for the landowners from the motivation payment
- annual income for the landowners from the decreasing value

Today only the blue value is paid for the construction of transmission lines in Germany **ONCE**!

Source:*Landwirtschaftliche Betriebsverhältnisse und Buchführungsergebnisse 2012

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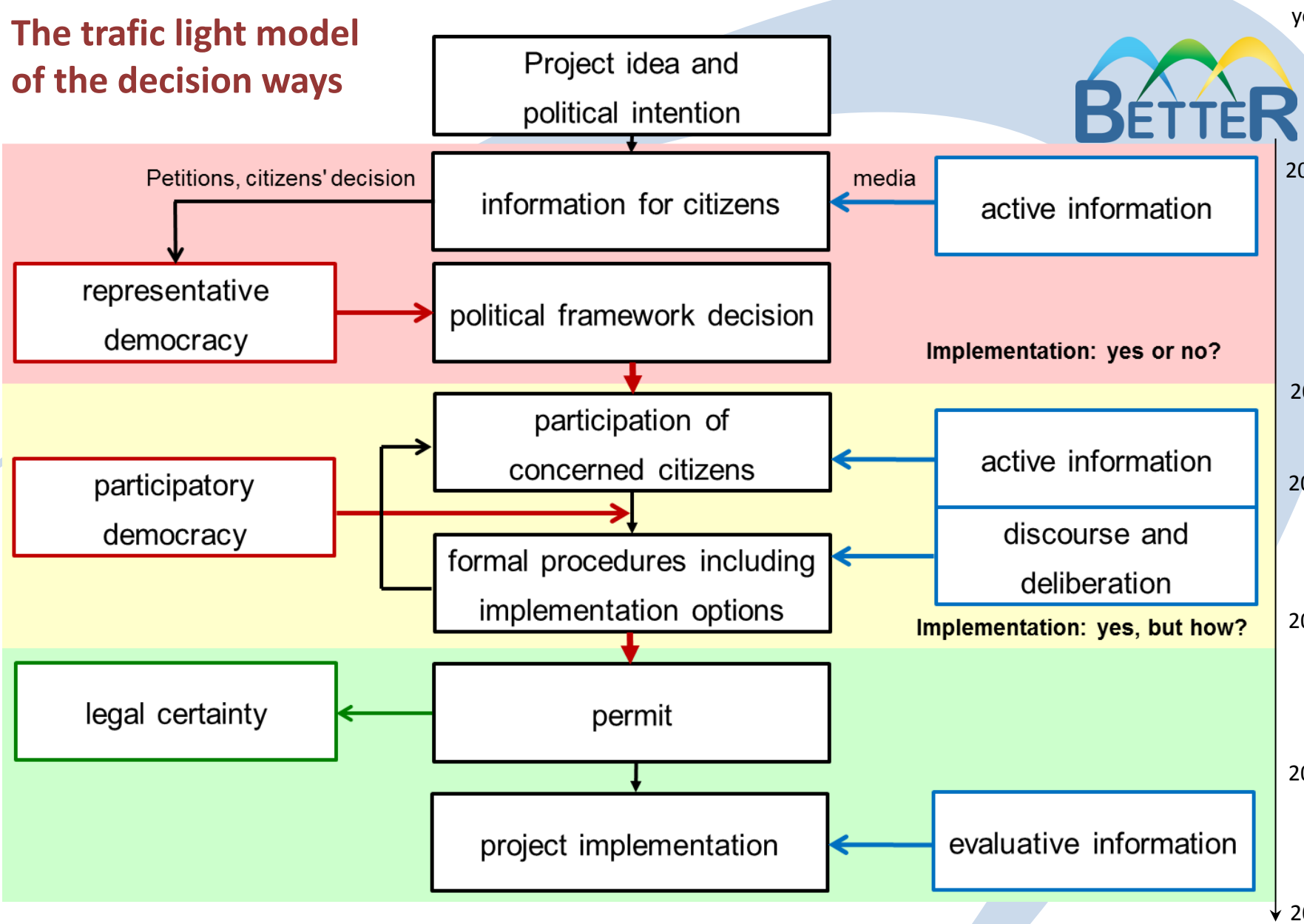
The trafic light model of the decision ways



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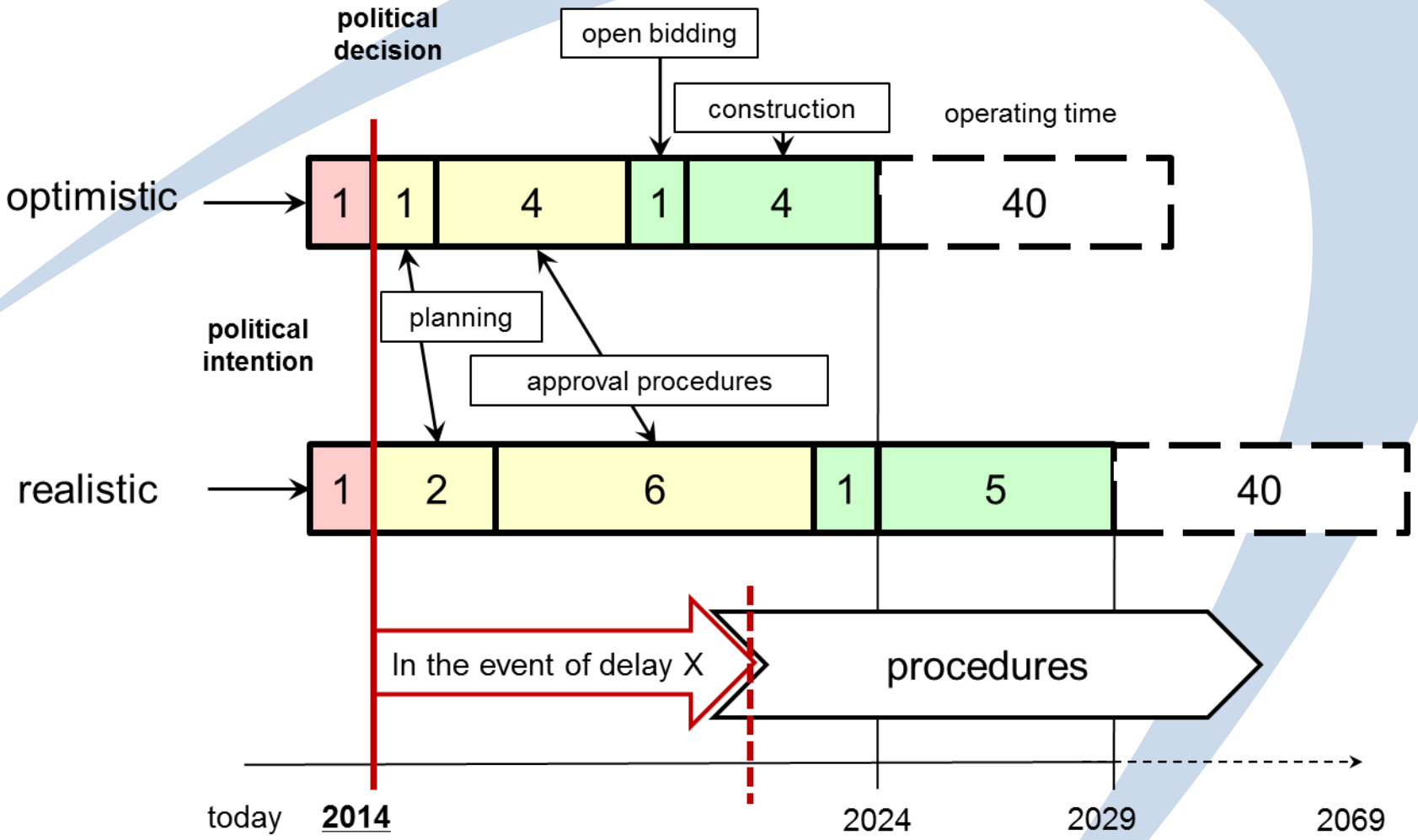
Time limit for a decision



How can the investment be paid that low interests incur and thus the capital costs remain low?

Investment:
16-23 billion €

!

capital costs

we need:
a short capital
repayment period

we need:
garantees
e.g.: AAA,
Power Purchase
Agreement (PPA)

!

The tariff will be high but only for a short time

In a european electricity market all consumers profit from constant cheap electricity
-> apportionment of the tariff on a high number of consumers

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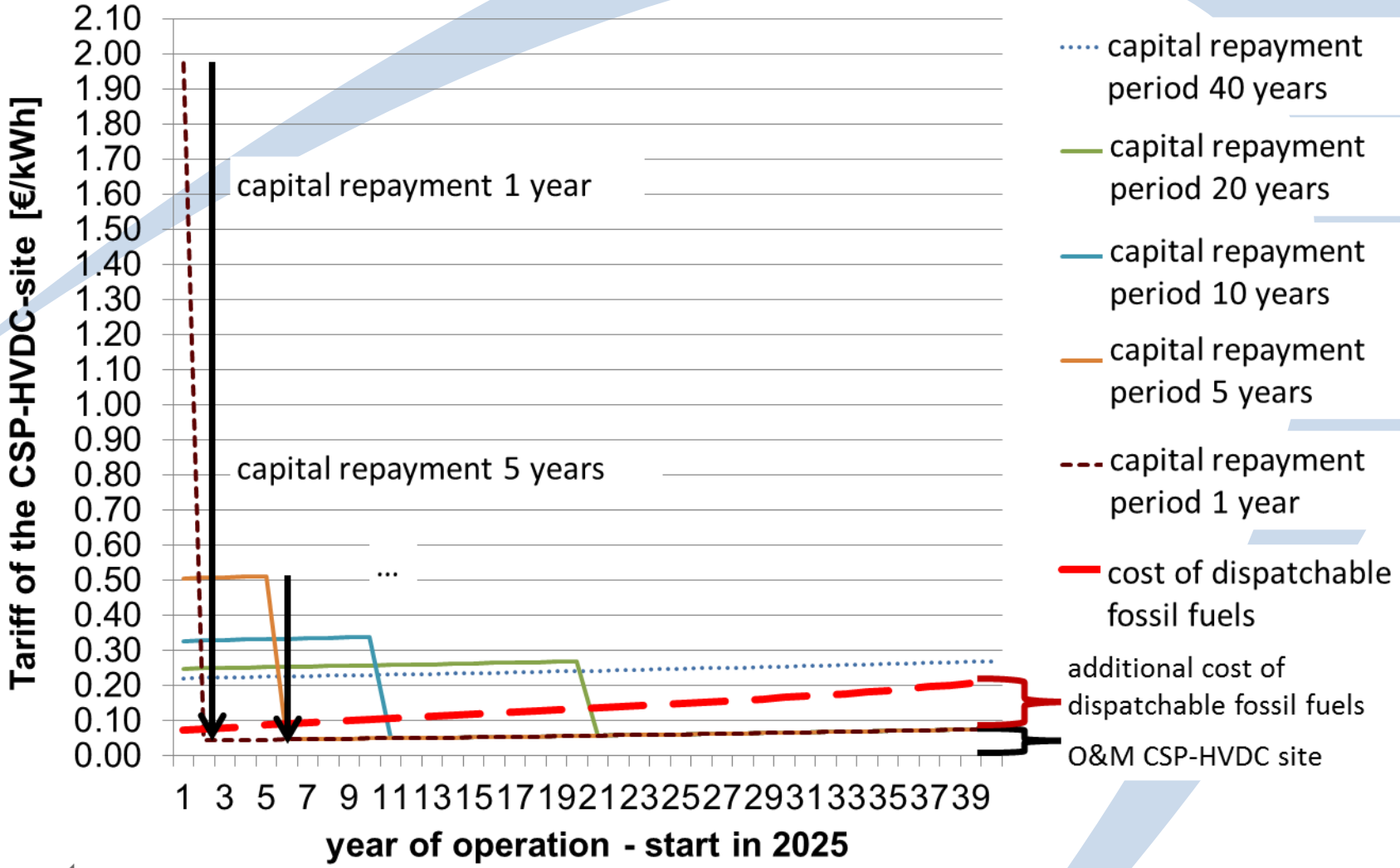
Tariff of the CSP-HVDC site Mis-Eic with underground cable - How can 16 billion € be paid that low interests incur and thus the capital costs remain low?



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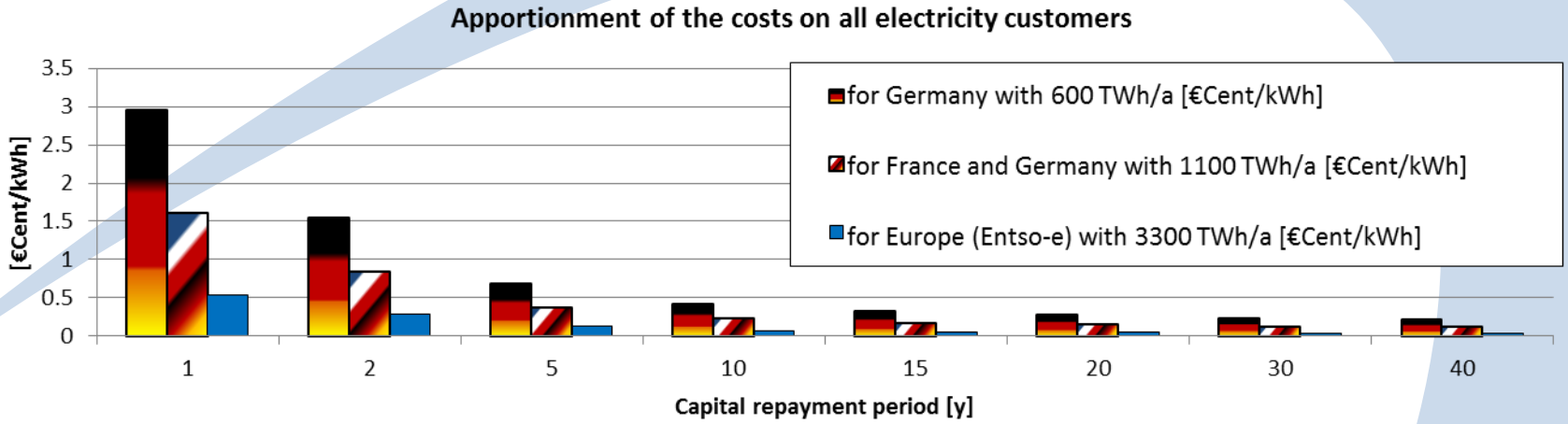
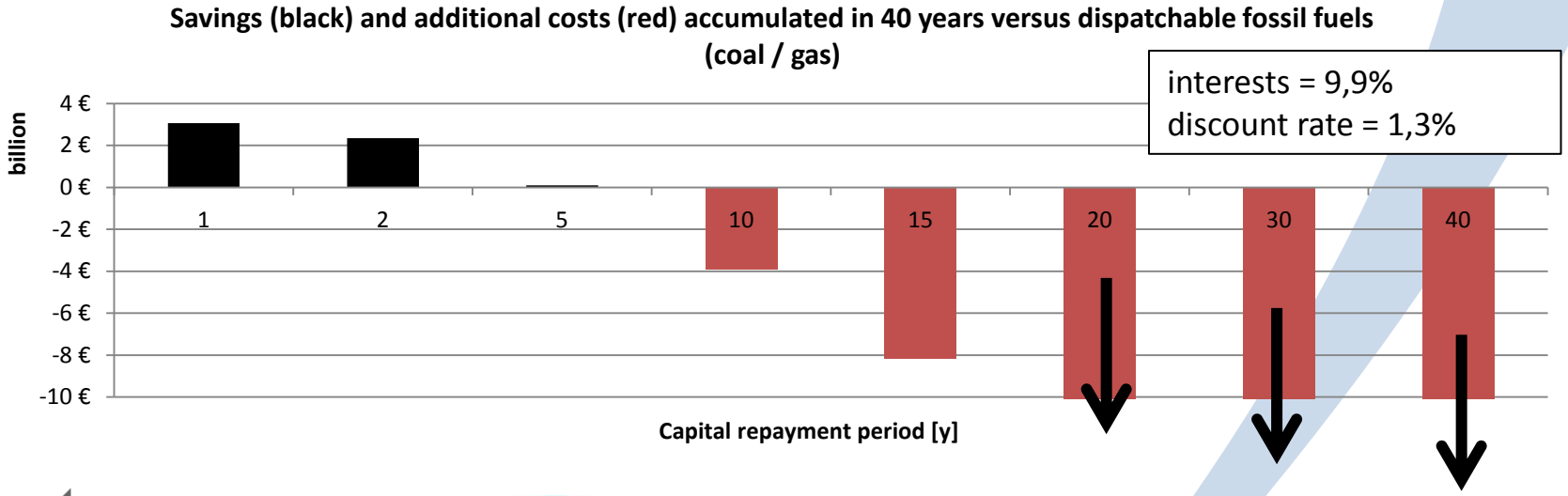
How can 16 billion € be paid that low interests incur and thus the capital costs remain low?





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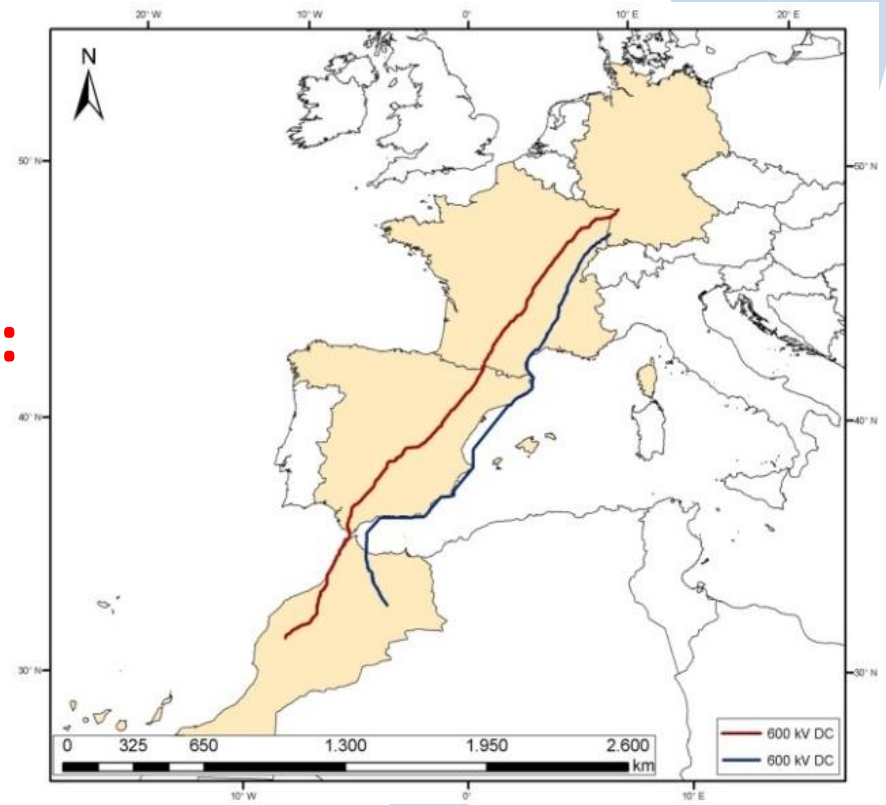
Conclusions

- For an electricity system with ~100% RE dispatchable renewable energy is necessary
- Only CSP with a new HVDC point-to-point infrastructure can enable an export of dispatchable renewable energy form North Africa to Europe
- A CSP plant with 150 km² needs only 0.8% of the potential in the northern part of Morocco
- The investment costs are at about 16-23 billion € for CSP and HVDC
- If we decide in 2013/2014 the project could be feasible until 2025
- Due to the compensation costs for the required land area, overhead transmission lines and underground cables can reach cost neutrality
- To avoid high capital costs garantees (AAA, PPA) and a short capital repayment period are needed

Transmission of dispatchable solar energy from North Africa to Central Europe

Communication platform for online public participation:

First ideas



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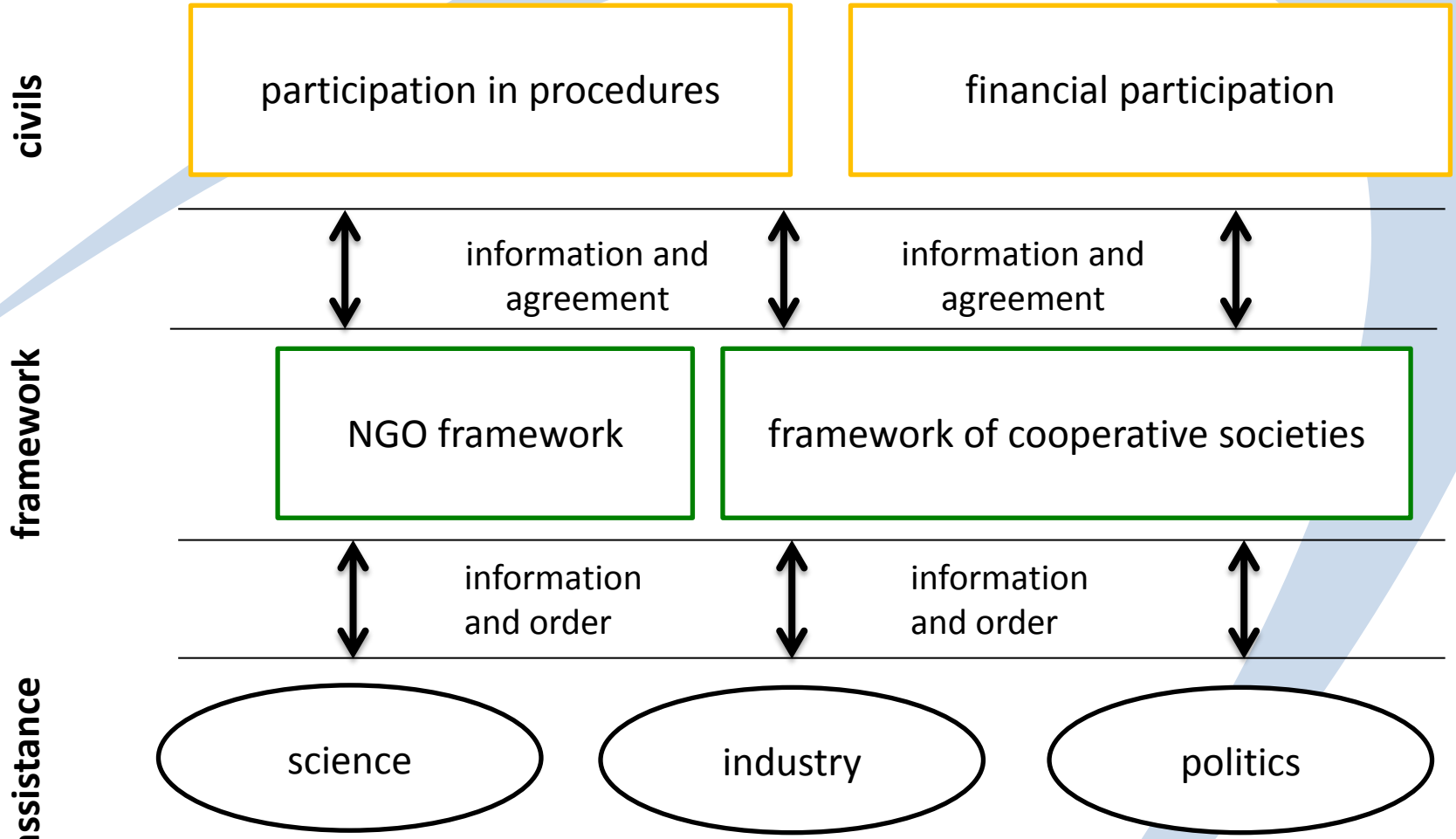
Potential information network for a multinational civil project



NGO: non-governmental organisation

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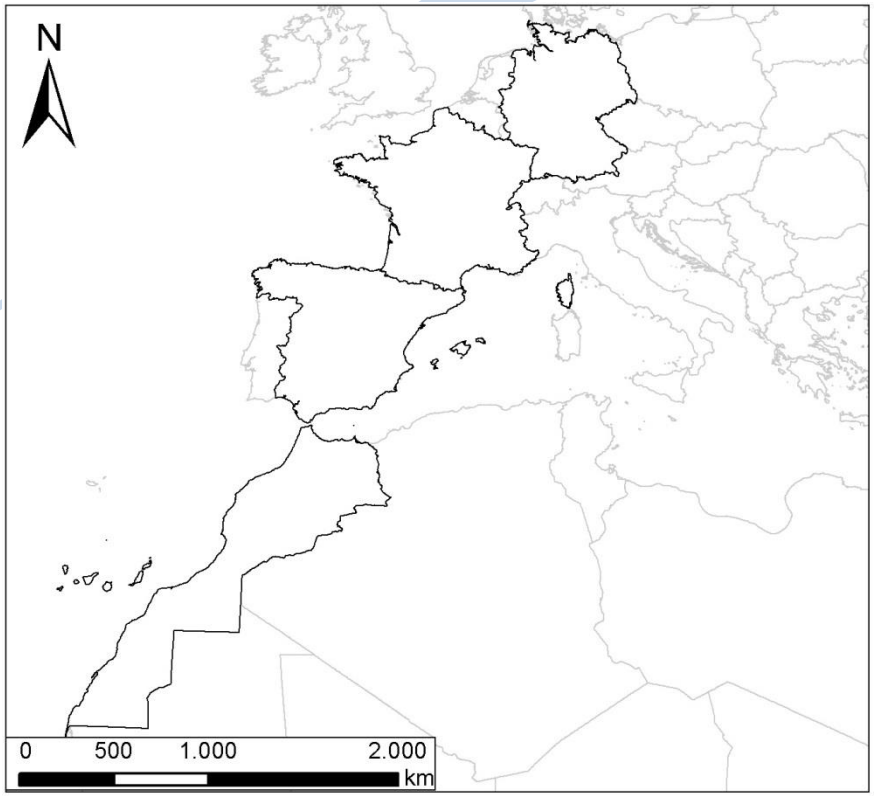
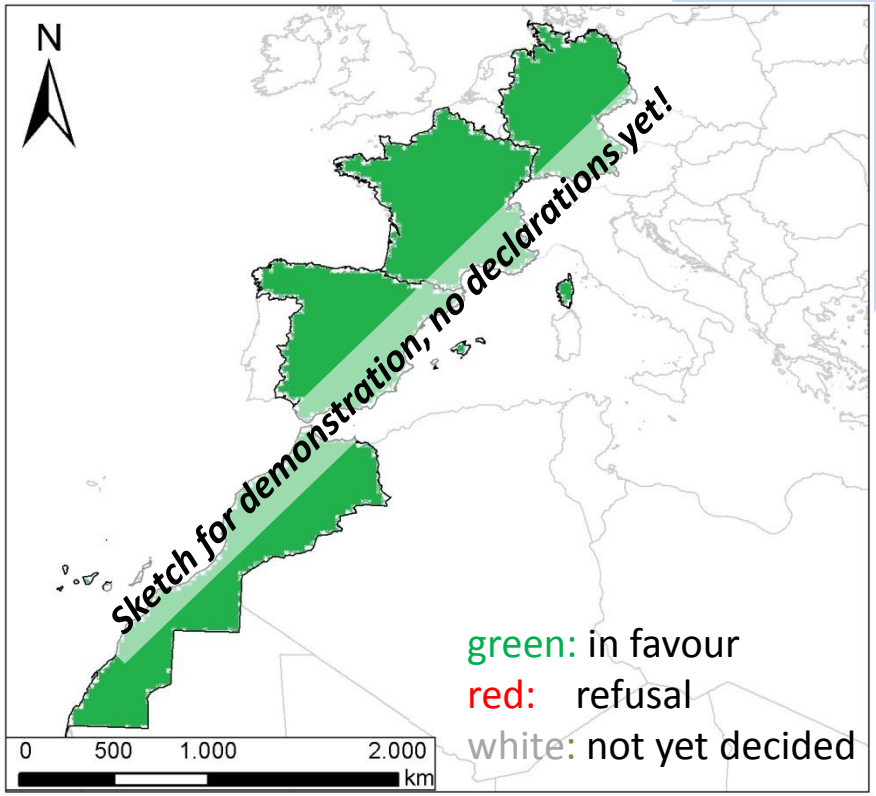
Declaration of intent on state level





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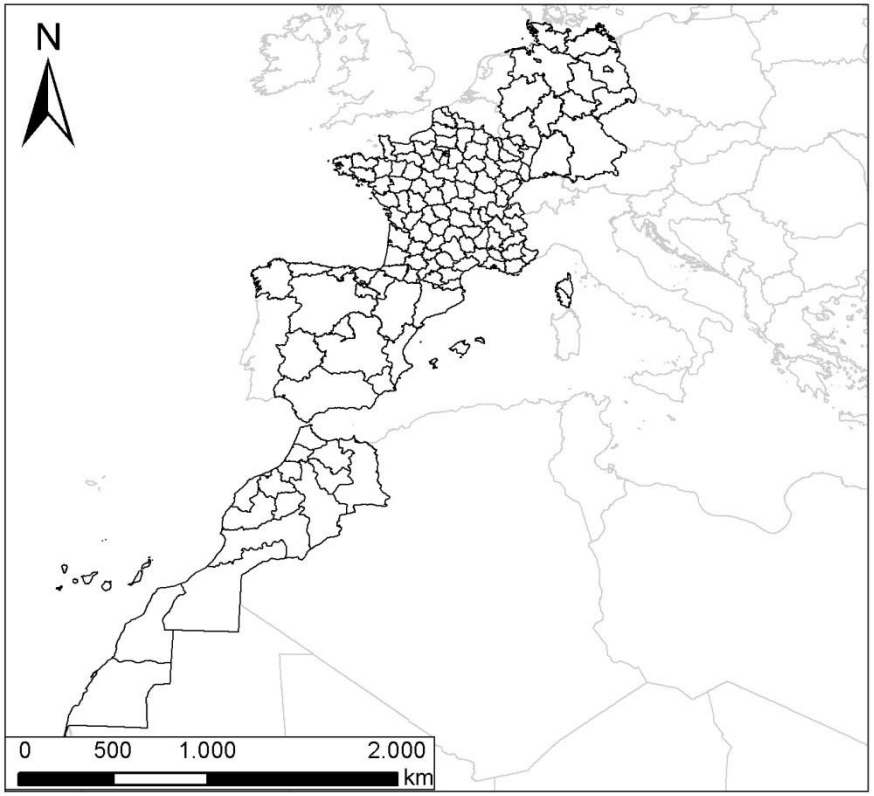
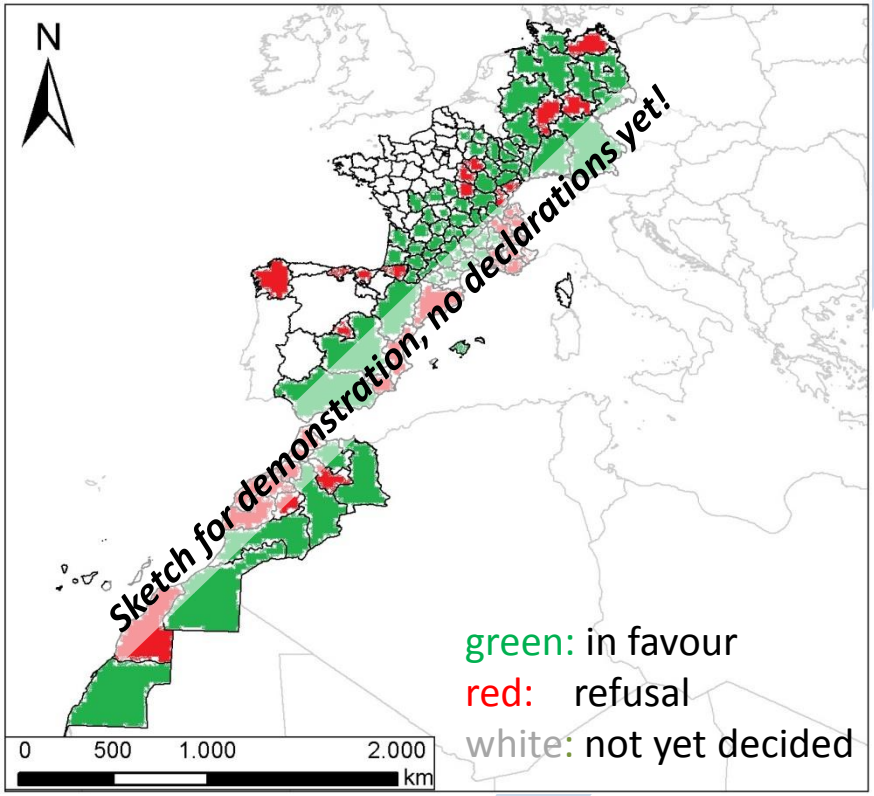
Declaration of intent on regional level





-> declaration for possible corridors

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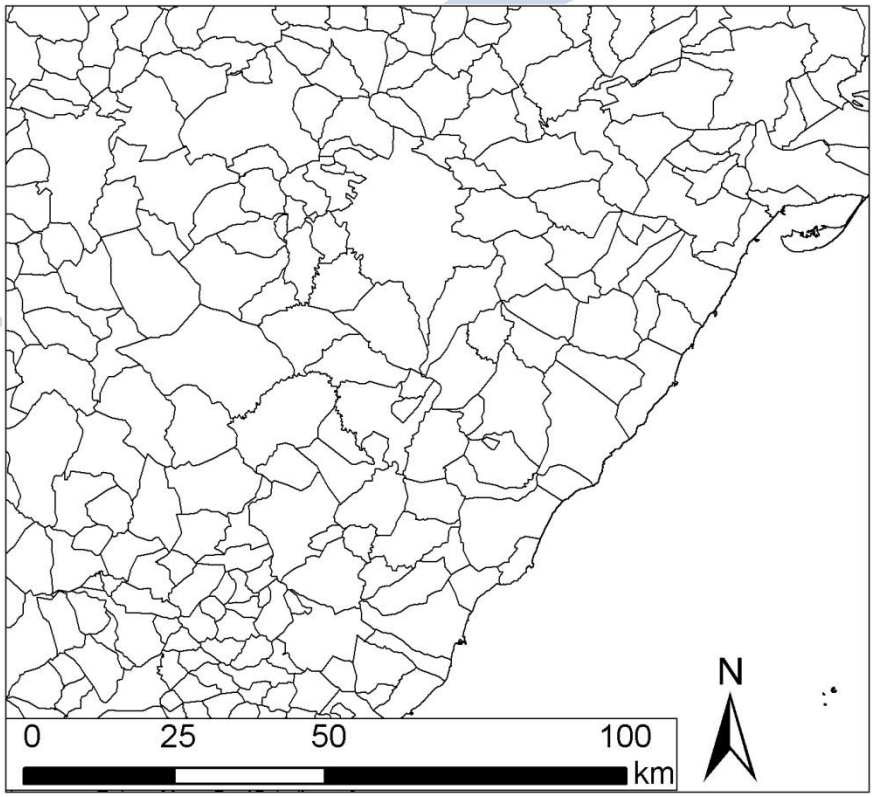
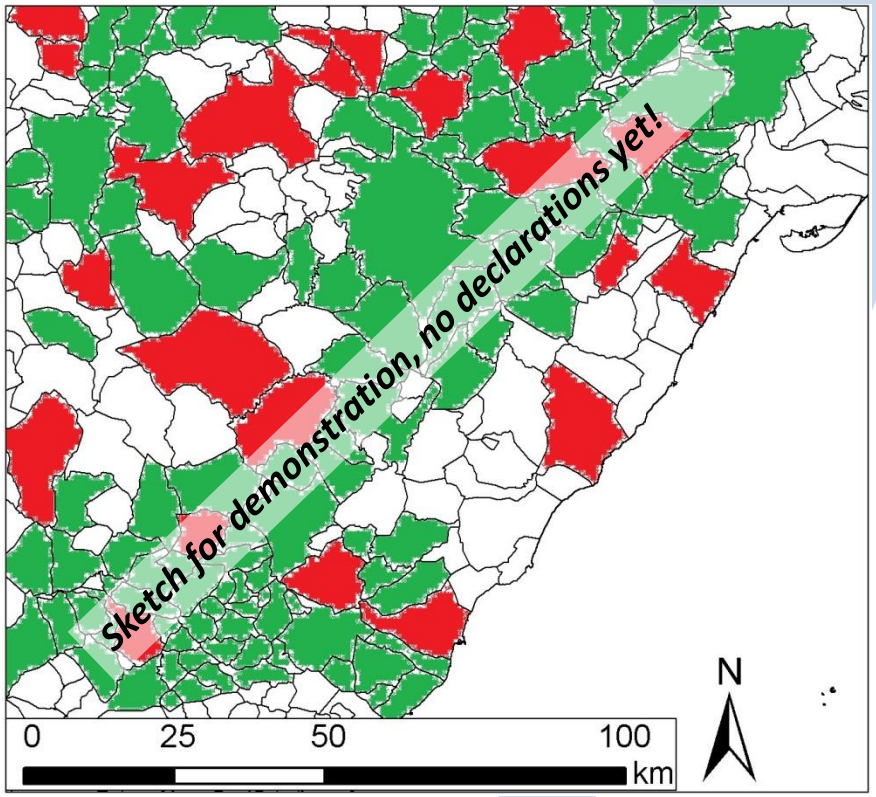
Declaration of intent on municipal level





-> declaration for possible corridors

green: in favour
red: refusal
white: not yet decided

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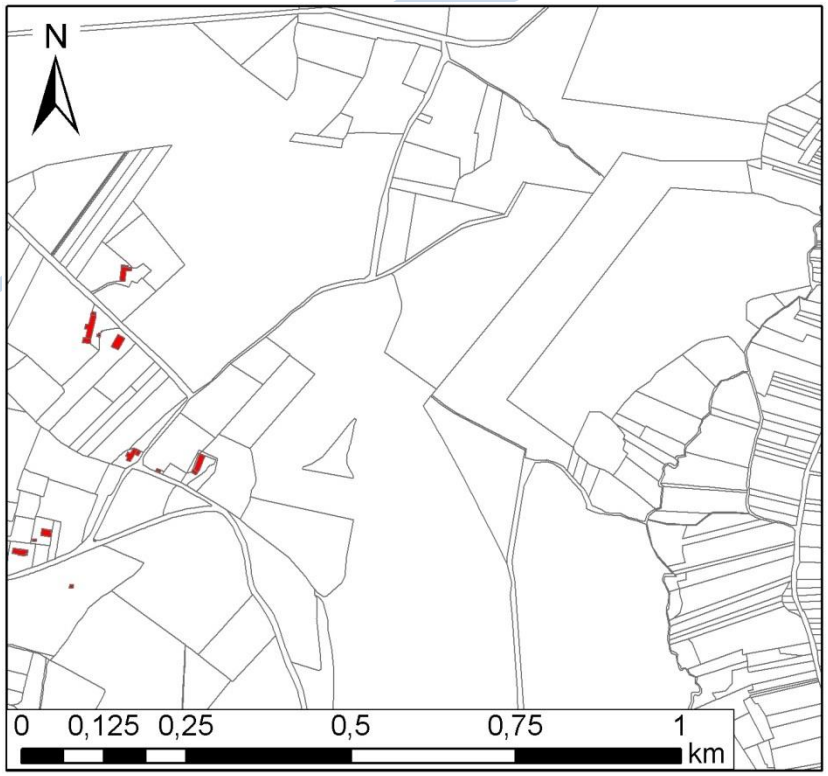
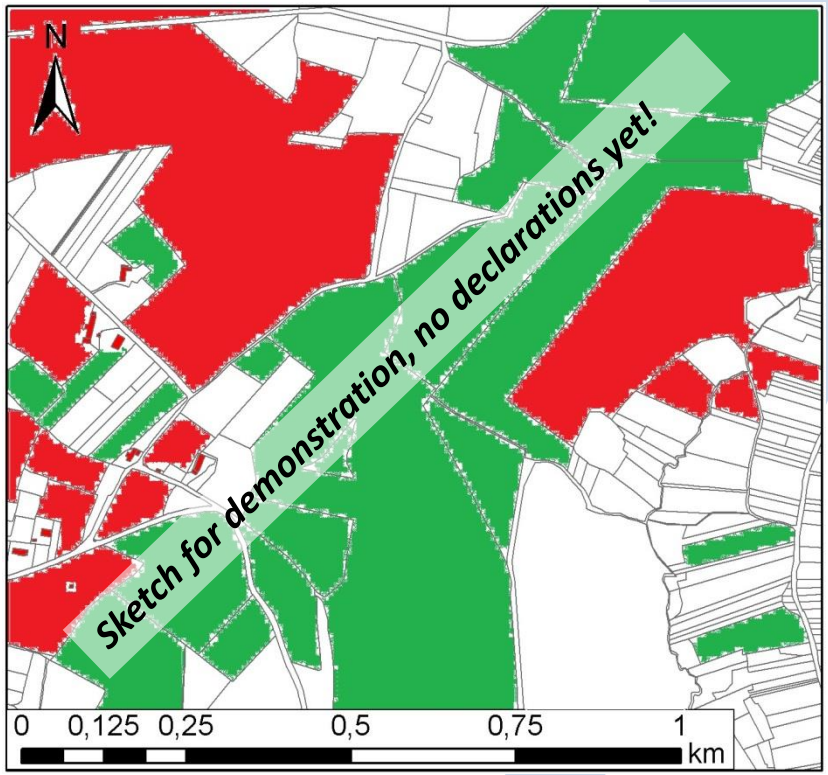
Declaration of intent on owner level





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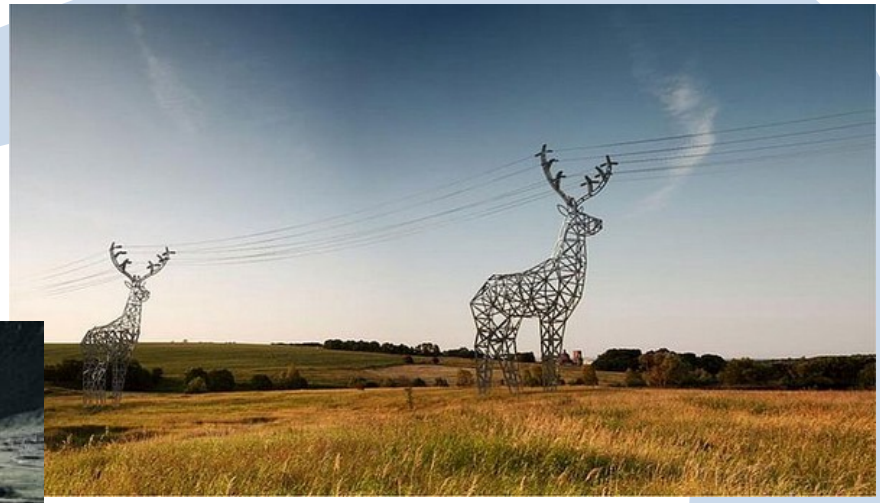
On the interactive website can also appear:

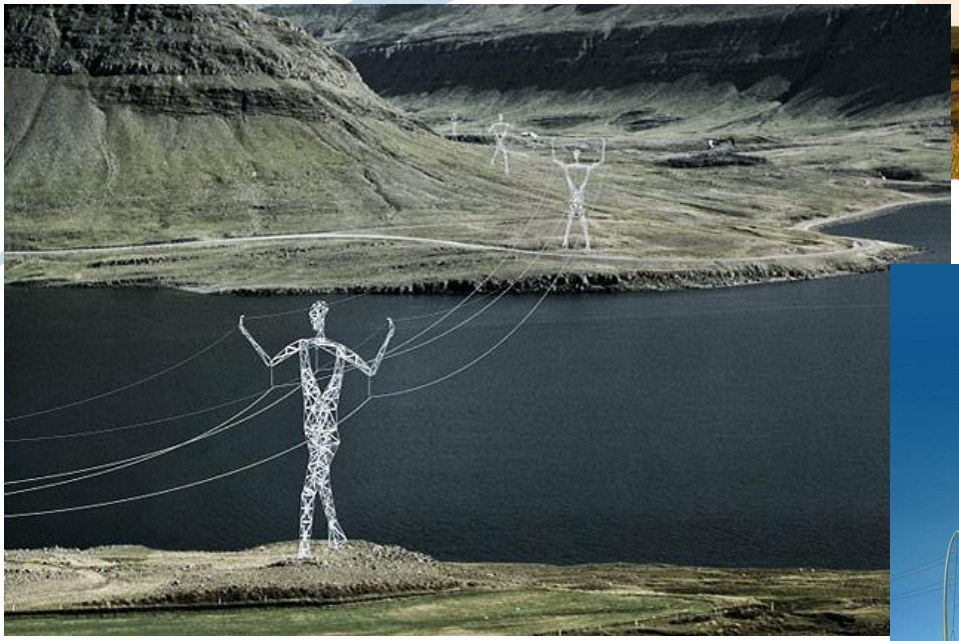
- Image video about this potential project (animation of the power plant function, need in the energy system of a Central European control area, data and interviews with affected people of the power station, the transmission line and electricity customers)
- All current activities with citizens, in politics, science and economy
- Schedule of citizen participation and overall schedule
- All data in the field of economy, ecology, technology, social and institutional
- Already achieved progress and critique

Further steps

- preparation of a handbook for public participation
- publication of further scientific studies on the necessity of dispatchable solar electricity imports to Baden-Wuerttemberg on a multilingual website
- questioning of citizens in case studies in exemplary communities
- detailed cost-benefit analysis with risk assessment
- cooperation with ENTSO, TransnetBW, RTE, REE, ONEE in preparation for the inclusion in the "Union List" of a project with common interests (EU Regulation 347/2013)
- support of the necessary application documents and the required measures
- search for suitable project responsible

„Ways connect people“





Thank you for your attention!

Source: http://www.ribapylondesign.com/

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Former projects related to the topics

- **MENA Regional Water Outlook** – CSP for Seawater Desalination in the Middle East and North Africa, World Bank (2012), www.dlr.de/tt/menawater
- **REACCESS** - Risk of Energy Availability: Common Corridors for European Supply Security, European Commission (2011), http://reaccess.epu.ntua.gr/
- **AQUA-CSP** - Concentrating Solar Power for Seawater Desalination, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2007), www.dlr.de/tt/aqua-csp
- **TRANS-CSP** - Trans-Mediterranean Interconnection for Concentrating Solar Power, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2006), www.dlr.de/tt/trans-csp
- **MED-CSP** - Concentrating Solar Power for the Mediterranean Region, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2005), www.dlr.de/tt/med-csp

Selected publications

- MED-CSP www.dlr.de/tt/med-csp
- TRANS-CSP www.dlr.de/tt/trans-csp and http://elib.dlr.de/83385/
- AQUA-CSP www.dlr.de/tt/aqua-csp
- MED-CSD www.med-csd-ec.eu/eng/
- MENA Regional Water Outlook www.dlr.de/tt/menawater
- Financing concentrating solar power in the Middle East and North Africa – Subsidy or investments? Energy Policy 39 (2011) 307-317 http://dx.doi.org/10.1016/j.enpol.2010.09.045
- Solar electricity imports from Middle East and North Africa to Europe Energy Policy 42 (2012) 341-353 http://dx.doi.org/10.1016/j.enpol.2011.11.091

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